Filtering Experiments on Marine Pelecypods from Tomales Bay, California

BY

DON MAURER

Old Dominion College, Biology Department, Norfolk, Virginia

FILTERING EXPERIMENTS WITH *Tellina buttoni, Tellina salmonea, Mysella tumida,* and *Transennella tantilla* have not been reported previously, although experimental work concerning the effect of turbidity, sedimentation, and substrate on mollusks is a broad field of research. Relation of filtering rates and feeding to high concentrations of microorganisms and suspended debris has been studied primarily with *Crassostrea virginica* (GMELIN, 1790), *Venus mercenaria* (LINNAEUS, 1758), and *Mya arenaria* LINNAEUS, 1758. LOOSANOFF & ENGLE (1940, 1947), LOOSANOFF & TOMMERS (1948), CHIPMAN & HOPKINS (1954), CHIBA & OHSHIMA (1957), RICE & SMITH (1958), JORGENSEN (1960), LOOSANOFF (1962), and ARMSTRONG (1965) represent a few of the publications in the field. In Tomales Bay, California MAURER (1966) described some pelecypod-sediment associations which included *Tellina buttoni* DALL, 1900, *T. salmonea* (CARPENTER, 1864), *Mysella tumida* (CARPENTER, 1864), *Lyonsia californica* CONRAD, 1837, and *Transennella tantilla* (GOULD, 1852). The writer concluded that sediment may be a limiting factor in determining the distribution, abundance, and size of these mollusks, but that not enough was known about the biological significance of sediment to bivalves to suggest an unequivocal causal relationship. Different conclusions among workers on the response of pelecypods to turbid water and sedimentation caution against broad generalizations to other species. In view of these opinions laboratory experiments on *Tellina buttoni, T. salmonea, Transennella tantilla,* and *Mysella tumida* were performed to better understand the effect of sediment and turbidity on clams in a natural situation. The results suggest that the ability to filter a medium and the degree of ingestion of particulate material may be factors which influence the distribution and abundance of bivalves to a particular sediment type.

METHOD

FOX, SVERDRUP & CUNNINGHAM (1937) described a method for determination of the average rate of water propulsion through gill chambers during normal feeding, respiratory, and excretory activities of *Mytilus californianus* CONRAD, 1837. LUND (1957) used an elaborate design for silting experiments with *Crassostrea virginica* and COUGHLIN & ANSELL (1964) described a direct method for determining the pumping rate of siphonate bivalves. The author followed the general design of Fox *et al.* and used a turbidimeter as outlined by LUND.

Mollusks were maintained in an outdoor sea water table which was attached to the laboratory and was shaded from sun and rain. Algae and diatoms which grew in the containers throughout the summer provided necessary food materials. During the course of the investigation temperature was measured periodically and was found to range approximately from 13.8° to 17.0° C. Daily range in temperature within the sea water system was about ± 1.5° C. Since temperature was so stable it was not included in Table 1 with the results.

In test procedure clams were placed in beakers with sea water and different concentrations of milk, india ink, carmine, and kaolinite. A control beaker of bivalves in sea water was included in each experiment. Milk was tried to determine if clearing experiments were feasible with species heretofore not considered in filtering studies. This was determined as follows. A 2 ml aliquot was removed from a beaker and placed in a Bausch and Lomb colorimeter. The colorimeter was set at 350 millimicrons. Percent transmission of light through a sample was taken as an indication of degree of clarity or turbidity of the sea water. A zero reading indicated that the water was opaque, while a 100% reading signified full transmission of light. It was observed that the mollusks cleared milk faster than it settled in the control beaker. India ink and carmine are within the size range of pelecypod food and vividly outline the digestive tract which makes them useful materials for purposes of dissection. Kaolinite is composed of the clay mineral kaolin which is a common constituent of estuarine waters and protected bays.

The type and concentration of the medium, initial and final colorimetric readings, elapsed time, and the number of test animals per species are summarized in Table 1. Initial colorimetric readings of test samples have been corrected to the initial colorimetric readings of the control sample. Total dry weight of tissues scraped from the shells and the average length of the test animals are also included in Table 1.

RESULTS

Experiment 1: At the finish of the experiment samples from all test beakers had less turbidity than the control sample. Beakers with *Tellina buttoni, T. salmonea,* and *Transennella tantilla* had a net increase in percent transmission of light, or clarity, of 27.6%, 4.5%, and 21.0% respectively.

Experiment 2: Results of the experiment showed that samples from test beakers with the tellinids were less turbid than the control sample, while the sample from *Transennella tantilla* was slightly more turbid than the control. *Tellina buttoni* and *T. salmonea* had a net increase in percent transmission of light, or clarity, of 14.0% and 8.0% respectively, and *Transennella tantilla* had a net decrease of 2.5%.

Experiment 3: Final colorimetric readings of test samples showed little or no increase in clarity over the control. Values among the test animals were very close with *Tellina buttoni* 0.0%, *T. salmonea* 3.0%, and *Transennella tantilla* 5.0%.

Experiment 4: At the termination of the experiment samples from test beakers with *Tellina buttoni* and *Transennella tantilla* were less turbid than the control sample, while the sample with *Tellina salmonea* was definitely more turbid than the control. *Tellina buttoni* and *Transennella tantilla* had a net increase in clarity of 9.0% and 9.5% respectively, whereas *Tellina salmonea* had a net loss of of 10.1%. Upon dissection it was found that in general the digestive tracts of a few *Tellina salmonea* were full of particles, but the majority contained very few ink particles. All specimens of *Tellina buttoni* had more ink particles in the mantle cavity and alimentary tract than *T. salmonea* and the small venerid *Transennella tantilla.* About one-third of the *Transennella tantilla* showed some particles in their intestines. The latter species also produced clumps of curlicue- and figure-8-like pseudofeces.

Experiment 5: Final readings in this experiment had all the test samples with less turbidity than the control. *Tellina buttoni, T. salmonea,* and *Transennella tantilla* had a net increase in clarity of 7.3%, 6.3%, and 6.8% respectively. Values among test animals were very close. Upon dissection, *Tellina salmonea* contained some carmine particles. Red, sausage-shaped pellets occurred throughout the intestine. Among these specimens there was very little siphonal activity following the experiment. Carmine particles occurred in greater amounts within *Tellina buttoni* than in *T. salmonea.* Sausage-shaped strings of carmine pellets were present in the intestine of *T. buttoni* as well. Three-fourths of the *Transennella tantilla* contained scarcely a trace of carmine, while in the other specimens the intestine was full of carmine.

Experiment 6: Samples from test beakers had only a marginal gain of clarity over the control sample. Indeed, the sample with *Tellina salmonea* was slightly more turbid than the control. Values among the test samples were close as *Tellina buttoni, T. salmonea,* and *Transennella tantilla* had differences from the control of 0.5%, —3.5%, and 5.5% respectively. *Tellina salmonea* contained only a trace of kaolinite and very few feces. Shell movement was not observed during or after the experiment. *Tellina buttoni* formed sausage-shaped and round pellets as well as string-like masses of pseudofeces. These clams moved horizontally and attempted to burrow during the experiment. *Transennella tantilla* formed masses of milky-white pseudofeces and contained some sausage-shaped pellets in the intestine.

Experiment 7: This was the only experiment in which *Mysella tumida* was used. Final reading showed that the test sample was less turbid than the control. Test sample had a net increase of 17% over the control.

DISCUSSION

Before results of the filtering experiments can be discussed an aspect of the study which was not treated should be mentioned. In order to compare the filtering rates of the tellinids, *Transennella tantilla,* and *Mysella tumida* it has been tacitly assumed that their ctenidial structure is comparable. Although the test species fit into the general category of eulamellibranchs, important modifications exist which certainly could influence filtering and feeding.

For example, *Transennella tantilla* is a venerid. Venerids, which usually feed as suspension feeders, have ctenidia with both inner and outer demibranchs and their palps are relatively small compared to the size of the gills. With *Transennella tantilla* Larson (1966) figured tissue connections between gill filaments which are characteristic of eulamellibranchs. From her figures it can be seen that the palps are considerably smaller than the ctenidia.

Table 1

Filtering Rate of Pelecypods as Determined using Sea Water Concentrations of Milk, Carmine, India Ink, and Kaolinite. Results Expressed in the Relative Percent of Light Transmitted through the Suspensions.

	Tellina buttoni	*Tellina salmonea*	*Transennella tantilla*	*Mysella tumida*	Control	Elapsed Time hours min.
1.						
Initial	–	–	–		24.5%	00:00
Final	59.1%	36.0%	52.5%		31.5%	29:00
Number of Specimens	10	10	10			
Concentration	0.8 ml milk/250 ml sea water					
2.						
Initial	–	–	–		28.0%	00:00
Final	51.0%	45.0%	34.5%		37.0%	29:15
Number of Specimens	10	10	30			
Total Dry Weight mg	0.1065	0.1014	0.0122			
Concentration	0.8 ml milk/250 ml sea water					
3.						
Initial	–	–	–		27.0%	00:00
Final	42.0%	45.0%	47.0%		42.0%	28:45
Number of Specimens	20	20	20			
Total Dry Weight mg	0.0301	0.0279	0.0116			
Concentration	0.8 ml milk/250 ml sea water					
4.						
Initial	–	–	–		12.0%	00:00
Final	94.5%	75.4%	95.0%		85.5%	22:15
Number of Specimens	11	10	10			
Total Dry Weight mg	0.0800	0.0739	0.0975			
Average length cm	1.10	0.87	0.51			
Concentration	1 ml ink/1000 ml sea water					
5.						
Initial	–	–	–		0.0%	00:00
Final	28.5%	27.5%	28.0%		21.2%	24:30
Number of Specimens	10	10	25			
Total Dry Weight mg	0.1267	0.0786	0.0741			
Average length cm	1.04	0.87	0.50			
Concentration	1 g carmine/1000 ml sea water					
6.						
Initial	–	–	–		41.0%	00:00
Final	87.0%	83.0%	92.0%		86.5%	07:00
Number of Specimens	10	10	21			
Total Dry Weight mg	0.0590	0.0601	0.1156			
Average length cm	1.20	0.83	0.48			
Concentration	1 g kaolinite /1000 ml sea water					
7.						
Initial				–	10.0%	00:00
Final				52.0%		
Number of Specimens				20		
Total Dry Weight mg				0.0884		
Average length cm				0.28		
Concentration				0.5 ml milk/50 ml sea water		

According to MORTON (1958) the genus *Mysella* belongs in the superfamily Erycinacea and many members feed as suspension feeders. In this group of bivalves the outer demibranch may be reduced or lost. YONGE (1949) has characterized the Tellinacea as deposit feeders. However, the mode of feeding of *Tellina buttoni* and *T. salmonea* does not entirely support this view. In some members of the Tellinacea the gill surface is much reduced in comparison with the labial palps which tend to approach the gills in size. As a result much of the sorting of particles which is performed by gills in suspension feeders is carried out by the labial palps in tellinids.

It would be expected with such basic differences in ctenidia and feeding behavior that the filtering rates would vary from one group to the next. Until the functional morphology of *Tellina salmonea, T. buttoni, Transennella tantilla,* and *Mysella tumida* is known and their mode of feeding has been observed, any conclusions drawn from the filtering experiments must be considered tentative. Reference to other species used in filtering experiments is necessary to outline the general features of the problem and to obtain independent evidence for one's work. Still, in light of structural modifications and different feeding behavior it should be emphasized that results of other studies should be applied cautiously, unless similar ctenidial and feeding types are compared.

In general the test animals cleared the milk-sea water colloids faster than coarse suspensions, and as would be expected, they had less difficulty clearing the milk than the particulate material. A relative estimate of filtering ability can be determined by ranking the pelecypods one, two and three in order of their final degree of clarity for each experiment. *Tellina salmonea* finished last considerably lower than either *Tellina buttoni* or *Transennella tantilla.* The latter two species both finished with 3 firsts, 2 seconds, and 1 third.

Mode of feeding might help to explain the different filtering rates of the pelecypods. Members of the Tellinacea have been considered deposit feeders by YONGE. Between *Tellina buttoni* and *T. salmonea* rates of filtering and amount of material ingested were so different that a similar feeding habit would seem unlikely. Further observations should confirm or negate the suggestion that these tellinids are not restricted to deposit feeding, but may exhibit a dual feeding habit.

Dissections indicated that *Tellina buttoni* ingested more carmine, kaolinite, and ink particles than either *Tellina salmonea* or *Transennella tantilla. Tellina buttoni* also produced more pseudofeces than the other species. Although this tellinid had some difficulty ingesting particulate matter under laboratory conditions, its ability to filter the suspensions indicated a greater tolerance to turbid conditions than *Tellina salmonea.* This might be a factor to explain its distribution and abundance in a range of sediment types wider than that of *T. salmonea.*

In view of the low filtering rates of *Tellina salmonea* it is understandable that less material was inhaled and thereby less opportunity offered for stuffing the palps and clogging the gills to occur. However, in contrast to *T. buttoni,* when *T. salmonea* ingested material it was able to process the particles through the alimentary tract as was evidenced by the sausage-shaped pellets in its intestine. Both feces and pseudofeces were produced. The apparent inability of *T. salmonea* to clear an artificial medium may be an indication of its mode of feeding and sensitivity to feed in turbid water and may help to explain its common distribution and abundance in clean, coarse sediments.

On the other hand, the small venerid *Transennella tantilla* combined the highest filtering rates with the least apparent difficulty of filtering the suspensions. Small tentacles surround the apertural margin of the siphons of *T. tantilla.* Such an arrangement suggests that the venerid probably feeds as a suspension feeder. The widespread occurrence of *T. tantilla* in various sediment types (MAURER, 1966) may be influenced by its ability to tolerate a certain degree of turbidity. This in turn may be controlled by its feeding apparatus. LIM (1966), who worked on a species of *Anadara* which lives in mud, discussed ciliary adaptations within pelecypods as related to environment or sediment type. He asserted that a large sorting area on the gills, well developed labial palps, more mucous secretion and ciliation of exposed parts presumably allowed the bivalve to cope with an environment of much silt and suspended particles in the surrounding water. Similar information on ciliary adaptations in *T. tantilla* would be most useful, but it should be remembered that the venerid is a lamellibranch and the arcid is a filibranch. Thus their response to the same turbidity might differ.

Insertion of *Mysella tumida* into the experiments indicated that this small species can be used in filtering experiments. BALLENTINE & MORTON (1956) have performed filtering experiments with *Lasaea rubra* MONTAGU, 1904, a closely related genus which is similar in size to *M. tumida.*

Further research with different concentrations of the same material, comparable sized species, greater control over water volume intake and oxygen, together with detailed knowledge of the functional morphology of the mollusks would improve the experimental design. LOOSANOFF (1962) commented on the radically different results obtained when mollusks are placed in small or large quantities of water during filtering experiments. He stated that a large mussel might rapidly clear a liter of water, whereas a mussel placed in a large quantity of water might become exhausted long before the turbidity was significantly lowered. The volume of water and the number of pelecypods per beaker used in the present experiments seem to be commensurate with the small size of the bivalves. It should be mentioned that exclusive of kaolinite the media (milk, india ink, carmine) are not normal constituents of the marine environment, and filtering rates measured may not reflect performances in the natural state.

ACKNOWLEDGMENTS

The research was carried out at the Pacific Marine Station, Dillon Beach, California, during the Summer of 1964. Dr. R. G. Johnson helped in many ways. Drs. Kent Price, Robert Puyear, and Edmund Smith kindly read the manuscript. Work was made possible by funds from a National Science Foundation cooperative grant in Oceanography made to the University of Chicago.

LITERATURE CITED

Armstrong, Lee R.
1965. Burrowing limitations in Pelecypoda. The Veliger **7** (3) : 195 - 200; 4 text figs. (1 January 1965)

Ballentine, Dorthy & John Edward Morton
1956. Filtering, feeding and digestion in the lamellibranch *Lasaea rubra*. Journ. Mar. Biol. Assoc. U. K. 35: 241 - 274

Chiba, K. & Y. Ohshima
1957. Effect of suspended particles on the pumping and feeding of marine bivalves, especially of the Japanese little neck clam. (in Japanese with English summary) Bull. Jap. Soc. Sci. Fish. 23: 340 - 353

Chipman, W. A. & J. G. Hopkins
1954. Water filtration by the bay scallop, *Pecten irradians*, as observed with the use of radioactive plankton. Biol. Bull. 107: 80 - 91

Coughlan, J. & Alen Ansell
1964. A direct method for determining the pumping rate of siphonate bivalves. Journ. Cons. Perma. Int. Explor. Mer. 29: 205 - 213

Fox, Denis L., H. N. Sverdrup & J. P. Cunningham
1937. The rate of water propulsion by the California mussel. Biol. Bull. **72**: 417 - 438

Jorgensen, C. B.
1960. Efficiency of particle retention and rate of water transport in undisturbed lamellibranchs. Journ. Conseil Intern. Explor. de la Mer 26: 94 - 116

Larson, Karen
1966. *Transennella tantilla*: the morphology of digestion and development. Unpubl. senior proj.: 1 - 7, figs. 1 - 17. Raymond College, California

Lim, C. F.
1966. A comparative study on the ciliary feeding mechanisms of *Anadara* species from different habitats. Biol. Bull. 130: 106 - 117

Loosanoff, Victor L.
1962. Effects of turbidity on some larval and adult bivalves. Proc. Gulf and Carib. Fish. Inst. 14th An. Sess., 80 - 94

Loosanoff, Victor L. & James B. Engle
1940. Effect of different concentrations of plankton forms upon shell movements, rate of water pumping and feeding, and fattening of oysters. Anat. Rec. **84**: 86
1947. Feeding of oysters in relation to density of microorganisms. Science 105: 260 - 261

Loosanoff, Victor L. & Frances D. Tommers
1948. Effect of suspended silt and other substances on the rate of feeding of oysters. Science 107: 69 - 70

Maurer, Don
1966. Pelecypod-sediment associations in Tomales Bay, California. Malacologia (in press)

Morton, John Edward
1958. Molluscs: An introduction to their form and functions. New York, Harper Bros. 232 pp.; 23 text figs.

Rice, T. R. & R. J. Smith
1958. Filtering rates of the hard clam *Venus mercenaria* determined with radioactive plankton. U. S. Fish & Wild Life Serv. Fish. Bull. 129: 71 - 82

Yonge, Charles Maurice
1949. On the structure and adaptations of the Tellinacea, deposit-feeding Eulamellibranchia. Phil. Trans. Roy. Soc. London, Ser. B. **234**: 29 - 76